PCT/AU2004/001401

AUSTRALIA

Patent Office
Canberra

I, JULIE BILLINGSLEY, TEAM LEADER EXAMINATION SUPPORT AND SALES hereby certify that annexed is a true copy of the Provisional specification in connection with Application No. 2003906600 for a patent by ORICA EXPLOSIVES TECHNOLOGY PTY LTD as filed on 28 November 2003.

COMMONWEALTH OF AUSTRALIA
AUSTRALIA
PATENT OFFICE

WITNESS my hand this
Twenty-second day of October 2004

J. Billingsley

JULIE BILLINGSLEY
TEAM LEADER EXAMINATION
SUPPORT AND SALES

Regulation 3.2

AUSTRALIA

Patents Act 1990

PROVISIONAL SPECIFICATION

for the invention entitled:

"Method For Multiple Blasting"

The invention is described in the following statement:

METHOD FOR MULTIPLE BLASTING

The present invention relates to a method of blasting, and is particularly concerned with a method of blasting multiple layers or levels of rock within mining operations, including layers that comprise waste material and/or recoverable mineral such as coal seams.

Current practices in open cut coal operations generally involve separate drill and blast cycles for blasting separate layers of material, such as waste or "burden" (over- and inter-) and coal. Similar practices are sometimes followed in the recovery of metal ores and, where appropriate, the present invention will be described in terms of "recoverable mineral" encompassing both coal, metal ores and other recoverable material of value. In the case of metal ores, blasts may be conducted in layers whose thickness is often dictated by equipment requirements rather than mineralogical formations. However, the principles of blasting multiple layers as described herein may be equally applicable to that case.

Typically, layers of overburden are drilled and fired separately to the underlying recoverable mineral seam and/or subsequent interburden layer(s) and recoverable mineral seam(s). Particularly in coal operations, overburden blasts may be undertaken as throw blasts to achieve productivity gains from moving some overburden to a final spoil position directly as a result of the blast. After complete excavation of the remaining overburden, the recoverable underlying mineral seam is drilled and blasted as a separate event, usually with quite different blast design parameters more suited to the recoverable mineral. In particular, the blasts in these layers are usually designed to minimise unwanted crushing, damage and displacement of the recoverable mineral. Similarly, the subsequent layers of interburden below the upper recoverable mineral seam(s), and further recoverable mineral seam(s) are usually also drilled and blasted in separate respective blast cycles.

A few operations undertake so-called "through-seam" blasting whereby overburden and underlying interburden are drilled and blasted in a single blast cycle, thus blasting through any intermediate seam or seams of recoverable mineral. These blasts are specifically

designed to minimise lateral movement of all of the material in order to avoid any disruption of the seam or seams of recoverable mineral, except possibly in a vertical sense but always with the goal of minimising dilution with the waste material. Thus, explosive powder factors in through-seam blasts are generally low and blast initiation timing that promotes forward or sideways movement of the material, such as used in throw blasting, is not employed in through-seam blasting. In conventional through seam blasting the delays between adjacent holes are designed to be the same for each layer blasted. Often through-seam blasting is used where the seam or seams of recoverable mineral are relatively thin, allowing the subsequent mining of such seams without the need to load explosives within the seam horizons in the blast field.

By way of example only, conventional through-seam or multi-layer blasting has been described in the following papers:

Burrell M.J.,1990. "Innovative Blasting Practice at Sands Hill Coal Company, Proceedings of the 16th Annual Conference on Explosives and Blasting Technique Orlando, Florida, USA, International Society of Explosives Engineers;

Chung S.H. and Jorgenson, G.K. 1985., "Computer Design and Field Application of Sub-Seam and Multi-Seam Blasts in Steeply Dipping Coal Seams", Proceedings of the Eleventh Conference on Explosives and Blasting Technique, San Diego, California, USA, International Society of Explosives Engineers; and

Orica Explosives, 1998. Safe and Efficient Balsting in Surface Coal Mines, Chapter 10, pp156-159.

Typically, mines that employ through seam blasting have situations of steeply dipping or undulating coal seams. Such situations do not favour conventional strip mining that employs throw blasting of the overburden since the overburden and coal do not occur in regular layers that can be blasted separately with conventional blast designs. The essence of through seam blasting is to drill long blastholes through the various layers of overburden and coal. In this process, the identification of the location of the coal seams within blastholes is essential. Explosive charging of the blastholes is then conducted according to the location of the coal seams. Reduced or nil explosive charges are employed

where the blastholes intersect the coal seams, in order to reduce damage and disruption of the coal seams.

Another paper, which describes an unconventional form of through-seam blasting, is Laybourne R.A., *et al.*, "The Unique Combination of Drilling and Blasting Problems Faced by New Vaal Colliery, RSA", 95th Annual General Meeting, Petroleum Society of CIM, 1993, No. 93, CIM Montreal. According to this paper multi-deck blasting was introduced in deeper areas of the colliery to ensure noise and vibration levels were kept within design requirements, as well as to minimize overall blast ratios. The paper also describes through-seam blasting in areas of the mine where some of the coal has previously been extracted by underground mining, leaving pillars of coal inbetween. The paper suggests that, while coal contamination was anticipated to be a problem when blasting the pillars, in practice no serious problems were experienced and the technique proved to be very successful. Additionally, the paper notes that it was theorised that improved results and less coal contamination would occur using delays between pillar charges and the charges in the interburden, but that test work was conducted to investigate the theory with no real improvement being determined.

Korean Patent Application 2003009743 describes a method of blasting multiple layers of rock.. Its purpose is to provide a more productive method for blasting a single rock mass while controlling vibration and other blasting environmental effects such as noise and flyrock, with the initiation direction being governed by the direction in which noise must be minimised. To achieve this, the rock mass is divided into multiple steps, with the length of the blastholes in the first step being determined by choosing a length appropriate to the minimum burden, the length of the blastholes of the second step being twice that of the first step, and the length of the blastholes of the third step being three times that of the first step. Equal blasthole spacings for each layer are proposed according to a very specific formula, and the order of initiation is specified as firstly the upper portion of the front row, then sequentially the lower portion of the front row, the upper portion of the next row, the lower portion of that row and so forth. The amount of explosives in each step may vary in order to achieve the same blasting effect in all of the blastholes.

It would be highly advantageous to provide a method of blasting that can increase overall mining productivity by allowing several layers of material to be blasted together within one drill and blast cycle in a more productive way than is currently provided by conventional blasting methods including through seam blasting, and this is the aim of the present invention.

According to a first aspect of the present invention there is provided a method of blasting plural strata of material including a first body of material comprising at least a first stratum of material and a second body of material comprising at least a stratum of overburden over the first body of material in a blast field having at least one free face at the level of the second body of material, the method comprising drilling blastholes in the blast field through the second body of material and, for at least some of the blastholes, at least into the first body of material, loading the blastholes with explosives and then firing the explosives in the blastholes in a single blast cycle of at least the first and second bodies of material, wherein the first body of material is subjected to a stand-up blast in said single blast cycle and said second body of material is subjected to a throw blast in said single blast cycle whereby at least a substantial part of the second body of material is thrown clear of the blast field beyond the position of said at least one free face.

Thus, differential blast outcomes, specifically in the first aspect of the invention differential forward movement of the material, are achieved for different rock strata. In particular, the first aspect of the invention involves the use of blasts that combine a throw blast design for overlying overburden with one or more stand-up designs for underlying interburden and/or recoverable mineral seams, in a single blast. Hence, the entire selected mass of material to be blasted, including for example overburden, interburden and recoverable mineral may be drilled and fired essentially as a single event.

Substantial productivity gains can be obtained by throw blasting the overburden where currently the overburden is blasted in a stand-up mode in through-seam blasting. Any throw of overburden into the final spoil position obtained using the method of the

invention translates into a corresponding direct increase in productivity. For the purposes of the present invention "at least a substantial part of the first body of material" means at least 10% of the first body of material. The preferred minimum amount thrown clear in a conservatively designed throw blast is in the range of 15 to 20%, and generally throw blasting can achieve a throw of 25% or more.

Productivity gains are additionally achieved by the first aspect of the invention from the reduction in drill and blast cycles. This alleviates the need for separate blast clean up, drill hole surveying and drill rig set up, explosive loading and blast firing steps in the mining sequence. In particular, the need for dedicated drill rigs and dozing equipment normally used in the separate drill and blast cycles of the mineral seams is elminated. Additionally, intermediate recoverable mineral seams that may have previously required separate blasting may not have to be blasted at all, instead being sufficiently broken by the underlying stand-up portion of the blast.

Furthermore, wall control may be facilitated by the first asepct of the invention, since highwalls do not have to be established prior to a separate recoverable mineral blast occurring. Since dedicated recoverable mineral blasts generally occur at the toes of such highwalls, they may damage the highwalls and lead to wall failure onto the recoverable mineral. Additionally, the faster access to the recoverable mineral achievable by the first aspect of the invention, since it now does not require a separate drill and blast cycle, will tend to reduce the likelihood of wall failures onto the recoverable mineral prior to its removal.

The second body of overlying material may comprise only overburden, while the first body of material preferably comprises recoverable mineral in one or more strata, and interburden in the case of two or more strata of recoverable mineral. However, this is not essential, since the first aspect of the invention can be applied to other combinations of layers of material. Such cases may include several layers of overburden and interspersed layers of recoverable mineral. The differential blast designs and outcomes in such cases of multiple layers may be made up of various combinations and sequences of the general case for two

layers as described herein. In one possible scenario, a third body of material, which may comprise one or more strata of burden and/or recoverable mineral, may lie between the first and second bodies. Such a third body of material may be subjected to, for example, a throw blast of different design and/or outcome to the second body of material. For instance, in the blast the third body of material might be thrown a greater or lesser distance than the second body of material. It is also conceivable that a further body of material, which might comprise a stratum of burden or recoverable mineral, overlies the second body of material and is subjected to a stand-up blast with the second body of material being subjected to the throw blast beneath it.

The differences in blast design in the bodies of material may be dictated by differences in rock properties, such as hardness, quality or whether it is recoverable mineral or not, as well as by the need to provide for a stand-up blast in at least the first body of material and a throw blast in at least the second body of material. Blast design features that may be varied for the bodies of material include blasthole pattern, explosive type, density, loading configuration, mass, powder factor, stemming and explosive initiation timing.

A primary parameter for achieving different outcomes in the different bodies of material in the blast field is different inter-hole and/or inter-row delays in the blasts in the different bodies. The different outcomes will be throw blasts versus stand-up blasts in a method according to the first aspect of the invention, but other differential outcomes may be desirable. Such other differential outcomes include fragmentation of the material. For example, it is often required to achieve fine fragmentation of overburden material to increase excavation productivity. By contrast, it is often required to achieve coarser fragmentation with more "lump" material in the recoverable mineral, particularly in the case of coal or iron ore. These requirements may be reversed for other minerals, for example in metalliferous or gold operations it may be desirable to achieve a finer fragmentation within the mineral layers than within the layers of waste material. This will increase the productivity of the downstream comminution processes of the ore.

Thus, according to a second aspect of the invention, there is provided a method of blasting

plural strata of material including a first body of material comprising at least a first stratum of material and a second body of material comprising at least a stratum of overburden over the first body of material, the method comprising drilling rows of blastholes through the second body of material and, for at least some of the blastholes, at least into the first body of material, loading the blastholes with explosives and then firing the explosives in the blastholes in a single blast cycle of at least the first and second bodies of material, wherein the second body of material is subjected to a blast of different design including inter-row and/or inter-hole blasthole delay times to that of the first body of material.

A reference to "inter-hole" herein is to the blastholes in any one row of blastholes. The distance between blastholes in any one row is known as the spacing. The distance between rows of blastholes is known as the burden, and the burden is generally greater than the spacing. Usually, where the blastfield has a free face, the rows of blasthoels will extend substantially in any one row need not be exactly aligned but may be offset from each other or form adjacent blastholes in the row.

In the second aspect of the invention, and depending upon the desired different blast outcomes between the bodies of material, the blast field may not have a free face, or may have a partial free face.

In either of the first and second aspects of the invention, any blasthole that does not extend into the first body of material way, but need not extend to the bottom of the second body of materials and the phrase "through the second body of material" shall be construed accordingly.

As noted above, the differential outcomes in the second aspect of the invention may comprise a throw blast in the second body of material and a stand-up blast in the first body of material and for convenience the second aspect of the invention will hereinafter be described with these differential outcomes in mind. Other aspects of the first aspect of the invention described hereinbefore may also apply individually or in combination to the second aspect of the invention.

By way of example, where the blasting is for the recovery of coal and the second body of material is overburden, the following blast design parameters may apply:

The "throw-blast" design may have, but not be restricted to, powder factors in the range 0.1-1.5 kg/m^3 (mass of explosive per unit volume of rock – typically 0.4-1.5 kg/m^3), blasthole spacings and burdens in the range 2m-20m (typically 5m-15m), blasthole depths in the range 2m-70m and any explosive type, density or loading configurations used in normal blasting operations. The inter-hole delays may be in the range 0-100 ms, (typically 1-30 ms) and the inter-row delays may be in the range of 0-2000ms (typically 50-500 ms). The "throw-blast" portion of the blastholes will generally fire before the "stand-up" portion of the blastholes, with a separation in time in the range of 0-30000 ms (typically 500-5000 ms). The "throw-blast" design will preferably have a free face and open void in front to allow the material to be thrown into the void.

The "stand-up" blast design may have, but not be restricted to, powder factors in the range 0.02-1.5 kg/m^3 (mass of explosive per unit volume of rock – but typically restricted to 0.05-0.4 kg/m^3), blasthole spacings and burdens in the range 2m-20m (typically 3-15m), blasthole depths in the range 2m-70m and any explosive type, density or loading configurations used in normal blasting operations. The inter-hole delays may be in the range 0-200 ms (typically 10-100 ms) and the inter-row delays may be in the range 0-2000 ms (typically 20-400 ms). The "stand-up" portion of the blastholes will generally fire after the "throw-blast" portion of the blastholes, with a separation in time in the range of 0-30000 ms (typically 500-5000 ms).

While a maximum delay of 30 seconds has been identified between the blasts in the first and second bodies, the blasts may be even longer then this, effectively without limit, in accordance with the invention, provided they are in the same mining cycle.

In one embodiment, a higher powder factor and explosive loading in the second body of

material, to be subjected to the throw blast, may be in the range 0.4 to 1 kg explosive per m^3 rock, as against 0.01-0.5 kg explosive per m^3 rock in the first body of material, to be subjected to the stand-up blast. The blasthole pattern in the blast field may have more blastholes in the second body of material than in the first body of material. Thus, some of the blastholes in the second body of material may not extend into the first body of material. The first body of material may have more inert decks, whether by way of stemming or air decks, and/or lower energy/density explosive than the second body of material. Inter-hole blast delays may be shorter (typically 0-3 ms per m spacing) in the second body of material than in the first body of material (typically >3 ms per m spacing) and inter-row delays may be greater (for example, > 5 ms per m burden, typically >10 ms/m) in the second body of material than in the first body of material (typically < 10 ms/m burden). The delay between the throw blast in the second body of material and the stand-up blast in the first body of material may be > 1 sec.

Thus, in a preferred embodiment of the first aspect of the invention and in accordance with the second aspect of the invention, the first body of material may incorporate different inter-hole and inter-row blasthole timing to the second body of material. The first body of material may also fire, with this different inter-hole and inter-row blasthole timing, a substantial time later than the second body of material, for example of the order of hundreds of milliseconds or even more than 1 second, thus allowing the second body of material to move laterally before the first body of material is fired. However, it may in some cases be desired to fire the first body of material before the second body of material. It may also be appropriate in some circumstances to reverse the direction of firing, thus firing some strata from the back to the front (free face end) and some in the opposite direction.

Advantageously, an electronic delay detonator system that preferably provides the features of a total burning front, delay accuracy and flexibility is used in the method of the invention. Electronic detonators, with accurately settable delays, may be essential to providing the desired inter-row and/or inter-hole blasthole delay times in accordance with the second aspect of the invention. The electronic detonators may be wired or wireless.

The use of wireless detonators may allow extended delays between the blasts in the first and second bodies.

The applicant's International Patent Application No. WO 02/057707 (and the corresponding United States National Phase Application filed 25 August 2003, under agent's reference 446-1581P) discloses preferred criteria for a throw blast using electronic detonators, and its full disclosure is incorporated herein by reference. That patent application describes blast design parameters suitable for throw blasting as well as for blasts that require restriction of forward movement of the muckpile. Methods disclosed in that patent application may be applied in the first aspect of the invention in throw blast and/or stand-up blast designs and in the second aspect of the invention for various blast layers as required.

Where the movement or breakage of a recoverable mineral seam, is required to be kept to a minimum and the seam is located adjacent to one or more other strata (such as waste material) that are required to be substantially broken or moved by the blast, explosive loading in, above and/or below the recoverable mineral seam should be substantially reduced or avoided altogether through the use of inert stemming material or air decks. Thus, some blastholes may be loaded with explosives in particular horizons and only lightly loaded, or left completely uncharged, in other horizons. It may also be appropriate to drill different blasthole patterns in the different horizons, whereby higher powder factors may be achieved in specific horizons by drilling more holes into that horizon, and *vice versa*, as discussed above. In a situation where there are two or more strata of recoverable mineral, the blastholes, or some of them, may not be drilled into the lowermost stratum of recoverable mineral.

It may be advantageous to provide for some buffering material at the level of the first body of material particularly where that body is subjected to a stand-up blast in accordance with the first aspect of the invention. The buffering may be provided by previously blasted or imported material and, in one embodiment, the method of the invention includes initially blasting, as part of the same blast cycle, a front row portion of the second body of material

such that it falls in front of the first body of material to provide a buffer when that body of material is blasted. This front row portion may not be drilled to the full depth of the second body of material and may have a blast design (eg. powder factor, loading and/or timing) that does not throw it too far, but just permits it to fall down the free face and lie in position in front of the first body of material. The main throw blast of the second body of material may then follow the initial blast after some delay. Such a delay may be as great as or, for example, substantially more than 1 second.

Various embodiments of a method of blasting in accordance with the present invention will now be described by way of example only, with reference to the accompanying drawings, in which:

Figure 1 illustrates a generalised concept of the method of the invention;

Figure 2 illustrates a first particular embodiment of the method of the invention;

Figure 3 illustrates a second particular embodiment of the method of the invention;

Figure 4 illustrates a third particular embodiment of the method of the invention;

Figure 5 illustrates a fourth particular embodiment of the method of the invention;

Figure 6a and 6b are plan and cross-sectional views, respectively, of a blast as described in the Example, which is in accordance with the embodiment of Figure 5; and

Figure 7 illustrates a blast in accordance with the invention which achieves a differential fragmentation outcome.

Figure 1 illustrates a generalised concept for blasting two or more strata of material in accordance with the first invention. A first body 10 of material is shown as extending beyond a free face 12 of a second body of material 14. However, as in the embodiments of

Figures 2 to 4, the free face 12 may extend to the bottom of the first body 10.

Each of the bodies 10 and 14 may have one or more strata of burden and/or recoverable mineral such as coal. Generally, but not necessarily, the second body 14 will be of one or more strata of overburden, while the first body 10 will have a stratum of recoverable mineral immediately below the second body 14, for example as illustrated in Figure 4. However, at least a second stratum of recoverable material may be disposed as the lower most stratum of the first body 10 with interburden between the or each two adjacent strata of recoverable mineral, as shown in Figures 2 and 3.

Returning to Figure 1, the blastfield 16 is shown as having six rows of blastholes, but any number and arrangement of blastholes may be provided in order to give the desired differential outcomes of blasts, in this case a throw blast of the second body 14 of material and a stand-up blast in the first body 10 of material. The blastholes are shown as vertical, but those in any one row may be inclined, for example by up to about 30 °.

As shown in this example, only some of the rows of blastholes, 18, 20, 22 and 24 along the blastfield 16 extend downwardly through both bodies 10 and 14 of material. The rows of blastholes 18, 20, 22 and 24 are approximately equally spaced, with the row 18 being the front row closest to the free face 12. Spaced between rows of the blastholes 18, 20, 22 and 24, in this case rows 18, 20 and 22, 24, may be further rows of blastholes 26 and 28, respectively, that extend downwardly only through the second body 14 of material. Such designs allow for more blastholes in one body of material, in this case the second body 14 of material. Higher explosive powder factors, for example to increase forward displacement of the second body of material 14, may be achieved differentially in the layers in this way.

Two decks of explosives material (shown as dark grey in the Figures and by reference numeral 46 in Figures 2 to 4), one in each of the first and second bodies 10 and 14 of material, are shown in each of the blastholes 18, 22 and 24. However, in this generalisation, only one deck of explosives, in the first body 10, is shown in blasthole 20.

Each of the shallower blastholes 26 and 28 also contains explosives material, with stemming material or air decks being provided between the two decks of explosives in the boreholes 18, 22 and 24, and stemming material being provided above the explosives in all of the blastholes. Each or any of the blasthole pattern, the explosive type, density and loading, the powder factor and the initiating timing in the two bodies of material may be varied to provide the throw blast of the second body 14 of material and the stand-up blast in the first body 10 of material. Additionally, the buffering provided by the continuity of the first body 10 of material forwardly of the free face 12 would be taken into consideration in designing the stand-up blast in the first body 10.

The throw blast should be designed to throw at least 10% of the material of the second body 14 forwardly onto the floor 30 of the void 32 in front of the free face 12. More preferably, at least 15 to 30% or even more of the second body 14 of material is thrown forwardly onto the floor 30 by the throw blast. The more material that is thrown forwardly onto the floor 30, especially beyond a position of final spoil of waste material the less mechanical excavation and clearance of the material in the second body 14 needs to be performed to expose the first body 10.

The stand-up blast in the first body 10 is designed to break up the first body, usually within several seconds after the throw blast in the second body, but without throwing the material of the first body forwardly. Thus, any strata of recoverable mineral in the first body of material will be broken up but not substantially displaced. Thus, once the blasted second body of material has been cleared from the blast field, the exposed first body 10 may be excavated immediately in the same mining cycle.

Figure 2 illustrates a specific embodiment of the generalised concept of Figure 1, with the same arrangement of rows of blastholes, and for convenience only the same reference numerals will be used as in Figure 1 where appropriate. Here there are four layers of material: a bottom coal seam 44 that is blasted with a stand-up blast design, an interburden layer 42 that is also blasted with a (different) stand-up blast design, a thin upper coal seam 38 that is suffciently thin not to require any blasting and an uppermost overburden layer 40

that is blasted with a throw blast design. Another major difference in Figure 2 is that the material of all of the layers of material ahead of the face 12 has been previously blasted and excavated so that the floor 34 of the void 32 in front of the face is at the level of the bottom of the first body 10 of material. Some previously blasted material on the floor 34 has been pushed into a pile 36 against the face 12 up to the level of the upper coal seam 38, to act as a buffer for the coal seams 38 and 44 and interburden 42 and enhance the stand-up blasts in those seams.

Decks 46 of explosives material are provided in each of the strata 40, 42 and 44, but not in the thin stratum 38 of coal. These decks would generally comprise different quantities and possibly types of explosive to provide different powder factors within each stratum. An electronic delay detonator 48, shown schematically, is provided in each of the decks 46 of explosives, and air decks or inert stemming are provided between and above the decks of explosives in each blasthole.

In this example, the detonators 48 in the decks 46 in the stratum 40 of overburden of the second body 14 are initiated first, in order from the front row of blastholes 18 rearwards. The blasthole pattern, explosive type, density and/or loading, the powder factor and/or the initiation timing in the stratum 40 are designed with the intent of throwing as much of the blast material from the stratum 40 as possible in the circumstances forwardly of the free face 12 onto the floor 34 of the void, especially beyond a final spoil position on the floor such that mechanical excavation of such thrown material is not required.

In the same blasting cycle and within seconds of the throw blast of the overburden, the explosive material in the strata 42 and 44 is initiated, with the blasthole pattern, explosive type, density and/or loading, the powder factor and/or the initiating timing being designed to create a stand-up blast in which the material of the three strata 38, 42 and 44 is broken up but otherwise minimally displaced or thrown forwardly. The stand-up blast in the stratum 42 may occur before, after or at the same time as the stand-up blast in the stratum 44, and in each of these strata the initiation may be from the front row of blastholes 18

rearwards, the opposite, all at the same time or otherwise.

Once the blast in the first and second layers 10 and 14 has been completed, the residual overburden from the second body 14 may be excavated, followed by the coal in the stratum 38, the interburden from the stratum 42 and, lastly, the coal from the stratum 44, all in the same mining cycle.

Turning now to Figure 3, the arrangement is very similar to that in Figure 2 and, again, for convenience only the same reference numerals will be used, as they will in Figure 4. Once again, the multilayer and blast consists of a stratum 40 of overburden, two strata 38 and 44 of coal and a stratum 42 of interburden. A buffer 36 of previously blasted material lies up against the free face 12 up to about the level of the top of the upper coal seam 38.

In this instance, only the four rows of through blastholes 18, 20, 22 and 24 are provided, and these are inclined with the toe towards the floor 34 and do not extend into the stratum 44 of coal. Thus, no explosives material is provided in the strata 38 and 44. Otherwise, the arrangement of decks 46 of explosives and electronic delays detonators (not shown) is similar to that in Figure 2.

Once again, the explosive type, density and/or loading, the powder factor and/or the initiation timing in the two strata of burden are designed to create a stand-up blast in the lower interburden stratum with minimal displacement or lateral movement of the coal seams and a throw blast of as much of the overburden 40 as possible in the circumstances. The design is also such that the coal in the stratum 44 is broken up, but not otherwise substantially displaced, by the blast at the toe of the blastholes in the interburden stratum 42.

In Figure 4, there is only a single stratum 38 of coal beneath the overburden 40, and in this instance decks 46 of explosives material are provided in the rows of blastholes 18, 20, 22 and 24 in the stratum 38, designed to break up the coal, but not otherwise displace it or dilute it with overburden material, in a stand-up blast. Again, the blast from the deck 46 of

explosives in the stratum 40 of overburden is designed to throw as much as possible of the overburden on to the waste pile 36, which acts as a buffer for the first body 10.

Figure 5 shows a modification to Figure 2. Here the front row of the overburden blast is fired first and some considerable time, of the order of seconds, earlier than the ensuing throw blast in the rest of the overburden material. This delay and the initiation timing of the entire blast are again provided by electronic detonators systems. The blastholes in this row need not be drilled to the full depth of the overburden but may instead only be drilled to a proportion of this depth. Alternatively, while Figure 5 shows this front row of the throw blast to extend downwards into the lower strata, this is not necessary and such holes may be confined to the overburden layer, and then also not necessarily to its full depth. This portion of the blast is designed with a low powder factor and an appropriate delay timing so as to ensure that the broken material falls directly in front of the underlying layers comprising stand-up blasts. In this way , this material automatically provides the buffer material for these blasts without the need to mechanically place such material in front of the blast block prior to any blasting. The ensuing throw blast and subsequent stand up blasts follow as described earlier herein. This technique may also be applied to blasts where the blastholes do not extend into the lower strata, such as in conventional throw blasts where the underlying coal seam is not blasted in the same blast cycle but it is still required to provide buffer material in front of the coal to restrict any displacement that may occur during the throw blast of the overburden material. In such cases, the front row of the throw blast may be designed as specified herein to automatically provide buffer material for underlying coal seams to restrict its forward movement, without the need for mechanical placement of such buffer material.

A typical example of the generic multi-blast as shown in Figure 5 is given here. This blast incorporates an initial small buffering blast and a subsequent throw blast within an upper overburden layer, an underlying coal seam that is not specifically blasted, an underlying interburden layer that is blasted with a stand-up blast design and an underlying coal seam that is subsequently blasted with a different stand-up blast design. In addition, this blast has a conventional "presplit" or "mid-split" row behind the back row of main blastholes.

This presplit row is very lightly charged and employs very short or zero inter-hole and inter-deck delays in order to form a crack network between holes that defines the new highwall for subsequent blasts. It may be timed to fire either before or during the throw blast portion of the multi-blast. All the aforementioned blasts within layers take place within a total time period of several seconds, hence all occurring within a single blast cycle on a mine. While this example shows all these various blast types within the multiblast, it is an example for demonstration purposes and any one or some of these component blasts is optional (for example, the buffering blast or presplit may be omitted, with corresponding adjustments made to the hole initiation times following the principles employed in the various blast sections in this example).

Figure 6a shows a plan view of the blastholes and Figure 6 b shows a cross-sectional view. There are six rows of main blastholes and a seventh row that is lightly loaded being the presplit row. The main rows of blastholes are loaded with explosives and timed to fire according to the desired blast outcome within the layer of rock containing each explosive deck, the layers being overburden, interburden or coal. Additionally, the uppermost deck of row 1 is designed differently to the other decks in order to act as an initial buffering blast. Furthermore, the presplit row is quite different to other rows being designed to form a clean new highwall for subsequent mining and blast cycles.

In this example, the depths of the strata are as follows:

Stratum 1: 20 m

Stratum 2: 4 m

Stratum 3: 15 m

Stratum 4: 10 m

In this example, there are additional rows, namely rows 2 and 5 in the uppermost (throw) layer of the multi-blast as compared to the lower (stand-up) layers. This provides a higher overall powder factor and more extensive distribution of explosives within this layer, promoting forward movement of this layer of the blast.

The blast pattern employed here is a nominal burden distance (between rows and between the front row and free face) of 7 m and a nominal spacing distance (between holes within rows parallel to the free face) of 9 m. The blastholes have a nominal diameter of 270 mm. The inter-row burden and the inter-hole spacings may vary from the front to the back of the blast. In this example, the inter-row burden between rows 3 and 4 is different, being 8 m in this example. The "stand-off" or separation distance between the back row of blastholes, row 6, and the presplit is 3 m at the collar. In this example, the presplit holes are inclined slightly while the other blastholes are vertical. Blasthole angle may change throughout the blast pattern as required. The inter-hole spacing between holes in the presplit row (row 7) is 4m. Note also that while electronic detonators are indicated in every explosive deck, this is not necessary in the presplit row, whose decks of explosive may be initiated by detonating cord within groups of ten holes while each group is initiated by an electronic detonator.

In this example, the number of holes per row is not specified, being a function of the overall size of blast to be fired along a mining strip. The first hole to be initiated is shown as the first hole of row 1, however the direction of initiation along the blast may be chosen according to site conditions, especially such that the blast initiates in a direction away from any areas that present the highest concern in terms of vibration and/or airblast. Alternatively, the blast may be initiated from a central position in both directions, following the design principles described here.

In this example the strata and rows are charged as follows:

Stratum 1: Row 1: ANFO explosive 250 kg. (Powder factor= 0.2 kg/m^3)

Stratum 1: Row 2 and Row 3: Heavy ANFO explosive 950 kg (Powder factor= 0.75 kg/m^3)

Stratum 1: Row 4: Heavy ANFO explosive 900 kg (Powder factor= 0.62 kg/m^3)

Stratum 1: Row 5 and Row 6: Heavy ANFO explosive 700 kg (Powder factor= 0.55 kg/m^3)

Stratum 1: Row 7(presplit): Waterproof emulsionexplosive in toe deck 60 kg, ANFO explosive in mid and upper decks 50 kg with air decks inbetween the explosive decks (Presplit Powder factor= 0.8 kg/m^2 of highwall area)

Note that the explosive charges in stratum 1 are located 3 m above the top of the upper coal seam, being loaded onto inert stemming material, thus providing an inert "stand-off" distance between the coal seam and the bottom of the explosive charges.

Stratum 2: All rows: Nil explosive charge, inert stemming material is backfilled into the holes through the coal seam stratum 2. This layer of inert material extends both below and above the coal seam for 3 m.

Stratum 3: Row 1: Heavy ANFO explosive 280 kg. (Powder factor= 0.30 kg/m^3)
Stratum 3: Row 3: Heavy ANFO explosive 620 kg (Powder factor= 0.33 kg/m^3)
Stratum 3: Row 4: Heavy ANFO explosive 350 kg (Powder factor= 0.33 kg/m^3)
Stratum 3: Row 6: Heavy ANFO explosive 570 kg (Powder factor= 0.30 kg/m^3)
Stratum 3: Row 7(presplit): Loaded as described earlier

Note that the explosive charges in stratum 3 are located 3 m above the top of the bottom coal seam, being loaded onto inert stemming material, thus providing an inert "stand-off" distance between the coal seam and the bottom of the explosive charges.

Stratum 4: Row 1: Waterproof emulsion explosive 160 kg. (Powder factor= 0.25 kg/m^3)
Stratum 4: Row 3: Waterproof emulsion explosive 320 kg (Powder factor= 0.25 kg/m^3)
Stratum 4: Row 4: Waterproof emulsion explosive 180 kg (Powder factor= 0.25 kg/m^3)
Stratum 4: Row 6: Waterproof emulsion explosive 250kg (Powder factor= 0.20 kg/m^3)
Stratum 4: Row 7(presplit): Loaded as described earlier

In this example the explosive charges in strata and rows are initiated as follows:

Stratum 1: Row 1: Zero milliseconds between holes in groups of 5 holes, with 25 ms between groups.

Stratum 1: Row 2 and Row 3: Row 2 commences 1500 ms after row 1. Row 3 commences 300 ms after row 2. Inter-hole delays of 10 ms are used in rows 2 and 3.

Stratum 1: Row 4: Row 4 commences 300 ms after row 3. Inter-hole delays of 10 ms are used.

Stratum 1: Row 5 and Row 6: Row 5 commences 300 ms after row 4 and row 6 commences 350 ms after row 5. Inter-hole delays of 15 ms are used in row 5 and inter-hole delays of 25 ms are used in row 6.

Stratum 1-4: Row 7(presplit): All decks within the presplit holes fire on the same delay. The presplit row is initiated in groups of ten holes all on the same hole delay, with 25 ms between groups of ten holes. The first group of holes initiates 150 ms after the first hole in row 2.

Stratum 3: Row 3: Initiated 500 ms after the first charge in Stratum 1 row 6. Inter-hole delays of 50 ms are used in this layer in row 3. This row is the first row to fire in this layer in order to provide initial breakage in the central zone and ensure minimal movement of the stand-up sections of the blast towards the free face.

Stratum 3: Row 4: Initiated 100 ms after the first charge in Stratum 3 row 3. Inter-hole delays of 50 ms are used in this layer in row 4.

Stratum 3: Row 1: Initiated 150 ms after the first charge in Stratum 3 row 3. Inter-hole delays of 50 ms are used in this layer in row 1.

Stratum 3: Row 6: Initiated 150 ms after the first charge in Stratum 3 row 4. Inter-hole delays of 50 ms are used in this layer in row 6.

Stratum 3: Row 7(presplit): Already initiated as described earlier.

Stratum 4: Row 3: Initiated 200 ms after the first charge in Stratum 3 row 6. Inter-hole delays of 50 ms are used in this layer in row 3.

Stratum 4: Row 4: Initiated 100 ms after the first charge in Stratum 4 row 3. Inter-hole delays of 50 ms are used in this layer in row 4.

Stratum 4: Row 1: Initiated 50 ms after the first charge in Stratum 4 row 4. Inter-hole delays of 50 ms are used in this layer in row 1.

Stratum 4: Row 6: Initiated 150 ms after the first charge in Stratum 4 row 4. Inter-hole delays of 50 ms are used in this layer in row 6.

Stratum 4: Row 7(presplit): Already initiated as described earlier.

This multi blast will yield the following:

1. A layer of buffering material from stratum 1 row 1 in front of the main (bottom) coal seam.
2. A substantial proportion of material from stratum 1 rows 2,3,4 and 5 thrown into a final spoil position, due to the combination of high powder factors and shorter inter-hole delays and longer inter-row delays, with initiation proceeding from the free face backwards into the blast block.
3. A presplit forming a clean highwall at the back of the entire blast block.

Stand-up blasts within strata 3 and 4,designed with lower powder factors, central initiation, longer inter-hole delays and shorter inter-row delays in contrast to stratum1, thus providing adequate breakage of material in Strata 2,3 and 4 to enable their excavation and recovery of coal but without substantial disruption or crushing, or dilution of the coal seams with the inter-or over-burden material.

Figure 7 shows an example of a multi-blast with specific designs for differential fragmentation outcomes within each of the separate layers. It shows an overburden layer on top of a recoverable mineral layer. While this example only shows two layers, several layers may be involved, each with similarly differential designs in order to achieve differential fragmentation outcomes.

The overburden layer has a blast designed to result in finer fragmentation for increased excavation productivity. By contrast, the recoverable mineral layer has a blast designed for coarser fragmentation to produce more "lump" material, which has a higher value for some minerals such as coal and iron ore. The use of different inter-hole and inter-row

timing as well as multiple in-hole initiation, all in combination with the higher powder factor in the overburden layer as compared to that in the mineral layer, enables the differential fragmentation outcomes to be achieved.

In Figure 7, there are six rows of blastholes numbered from 1 to 6. In this example, only four rows, namely rows 1,3,4, and 6, extend into the mineral layer below. The nominal blasthole diameter is 270 mm and the nominal burden distances between rows and spacing distances between holes within rows are 7 m and 9 m respectively. The depth of the overburden layer is 40 m and that of the mineral layer is 10m.

In this example, the number of holes per row is not specified, being a function of the overall size of blast to be fired along a mining strip. The first hole to be initiated is taken as the first hole of row 1, however the direction of initiation along the blast may be chosen according to site conditions, especially such that the blast initiates in a direction away from any areas that present the highest concern in terms of vibration and/or airblast. Alternatively, the blast may be initiated from a central position in both directions, following the design principles described here.

In this example the strata and rows are charged as follows:

Stratum 1: Row 1: Heavy ANFO explosive 2000 kg. (Powder factor= 0.79 kg/m^3)
Stratum 1: Rows 2, Row 3, 4 and 5: Heavy ANFO explosive 1800 kg (Powder factor= 0.71 kg/m^3)
Stratum 1: Row 6: ANFO explosive 1400 kg (Powder factor= 0.56 kg/m^3)

Note that the explosive charges in stratum 1 are located 3 m above the top of the upper coal seam, being loaded onto inert stemming material, thus providing an inert "stand-off" distance between the coal seam and the bottom of the explosive charges.

Stratum 2: Row 1: Heavy ANFO explosive 200 kg. (Powder factor= 0.32 kg/m^3)
Stratum 2: Row 3: Heavy ANFO explosive 400 kg (Powder factor= 0.32 kg/m^3)

Stratum 2: Row 4: ANFO explosive 150 kg (Powder factor= 0.24 kg/m^3)

Stratum 2: Row 6: Heavy ANFO explosive 400 kg (Powder factor= 0.32 kg/m^3)

In this example the explosive charges in strata and rows are initiated as follows:

In all blastholes in stratum 1, dual in-hole initiation used. In this example, the "initiators" comprise an electronic detonator within a suitable primer. In stratum 1, the bottom initiator in each hole fires first with top initiator delayed by 2 ms from the bottom initiator, thus enabling detonation both downwards as well as upwards within each column of explosive within stratum 1.

Stratum 1: Row 1: 12 ms delay between holes.

Stratum 1: Rows 2, 3, 4 and 5 : Row 2 commences 100 ms after row 1. Rows 3, 4 and 5 commence 150 ms after the preceding row. Inter-hole delays of 12 ms are used in rows 2, 3, 4 and 5.

Stratum 1: Row 6: Row 6 commences 150 ms after row 5. Inter-hole delays of 26 ms are used in row 6.

Stratum 2: Row 3: Initiated 1500 ms after the last charge in Stratum 1 row 6. Inter-hole delays of 60 ms are used in this layer in row 3.

Stratum 2: Row 4: Initiated 150 ms after the first charge in Stratum 2 row 3. Inter-hole delays of 60 ms are used in this layer in row 4.

Stratum 2: Row 1: Initiated 150 ms after the first charge in Stratum 2 row 4. Inter-hole delays of 60 ms are used in this layer in row 1.

Stratum 2: Row 6: Initiated 200 ms after the first charge in Stratum 2 row 4. Inter-hole delays of 70 ms are used in this layer in row 6.

This multi-blast will yield finer fragmentation in the overburden layer in stratum1 and coarser fragmentation with more "lump" material in the mineral layer in stratum 2.

Those skilled in the art will appreciate that the invention described herein is susceptible to

variations and modifications other than those specifically described. It is to be understood that the invention includes all such variations and modifications which fall within the spirit and scope. The invention also includes all of the steps, features, compositions and compounds referred to or indicated in this specification, individually or collectively, and any and all combinations of any two or more of said steps or features.

Throughout this specification and the claims which follow, unless the context requires otherwise, the word "comprise", and variations such as "comprises" and "comprising", will be understood to imply the inclusion of a stated integer or step or group of integers or steps but not the exclusion of any other integer or step or group of integers or steps.

The reference to any prior art in this specification is not, and should not be taken as, an acknowledgment or any form of suggestion that prior art forms part of the common general knowledge in Australia.

Dated this 28th day of November, 2003
Orica Explosives Technology Pty Ltd
By Its Patent Attorneys
DAVIES COLLISON CAVE

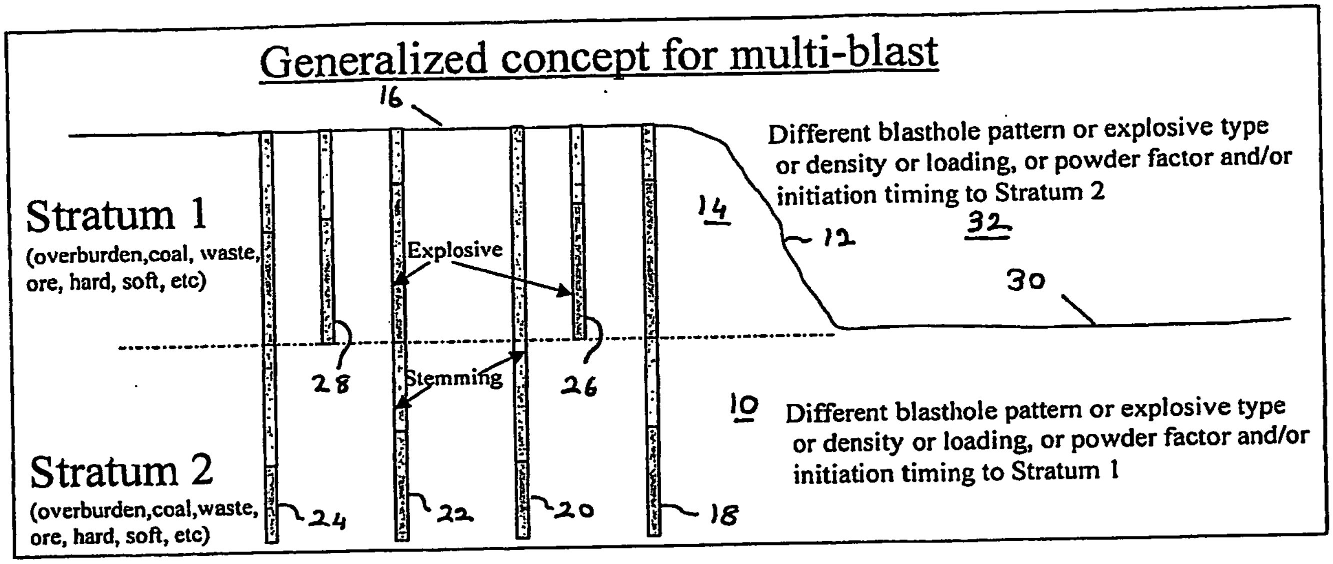

Figure 1

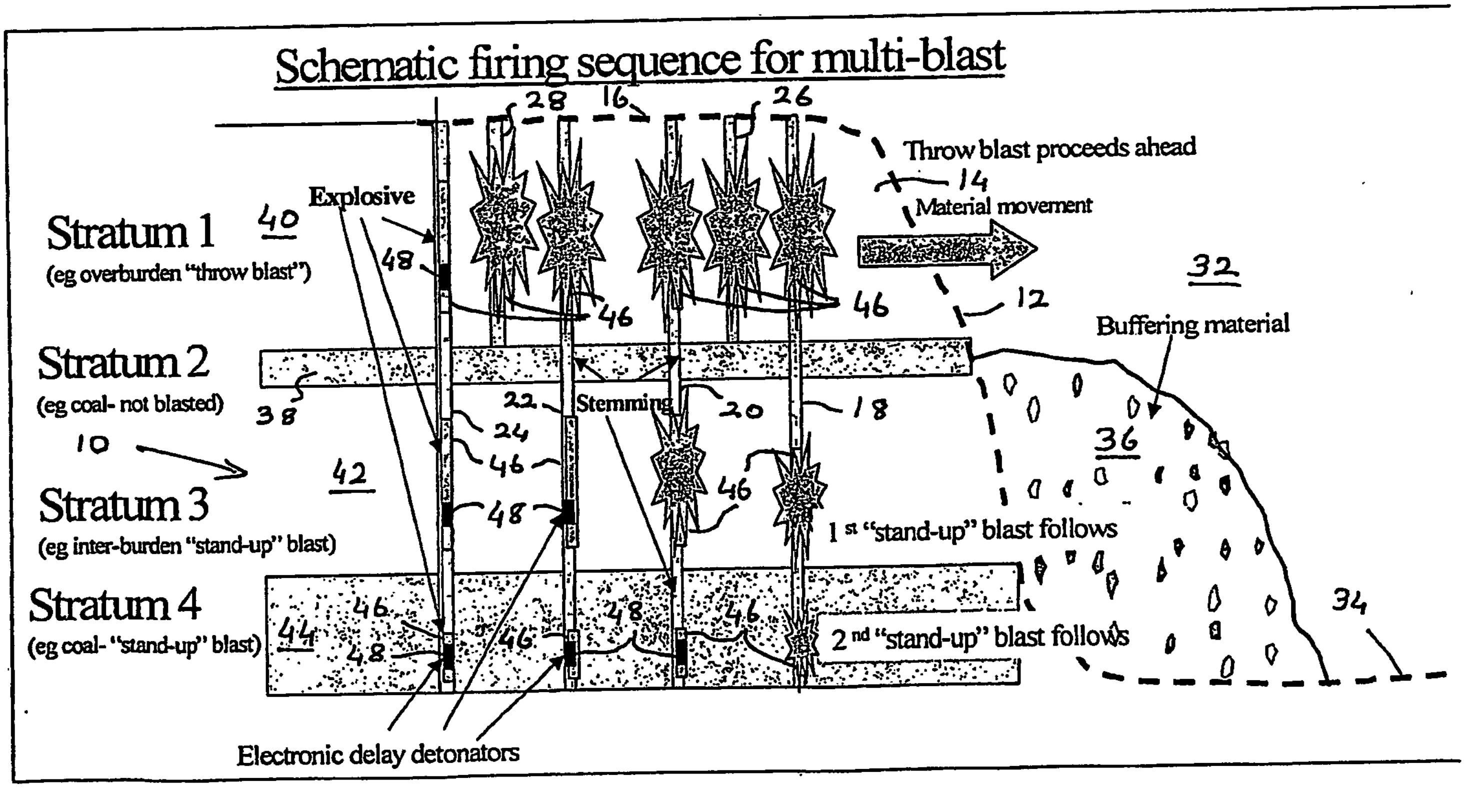

Figure 2

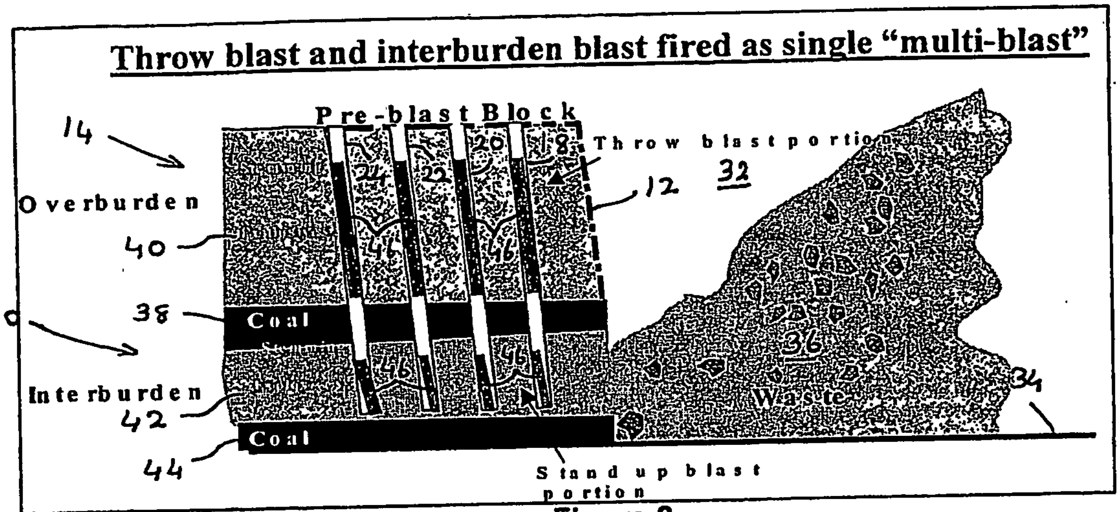

Figure 3

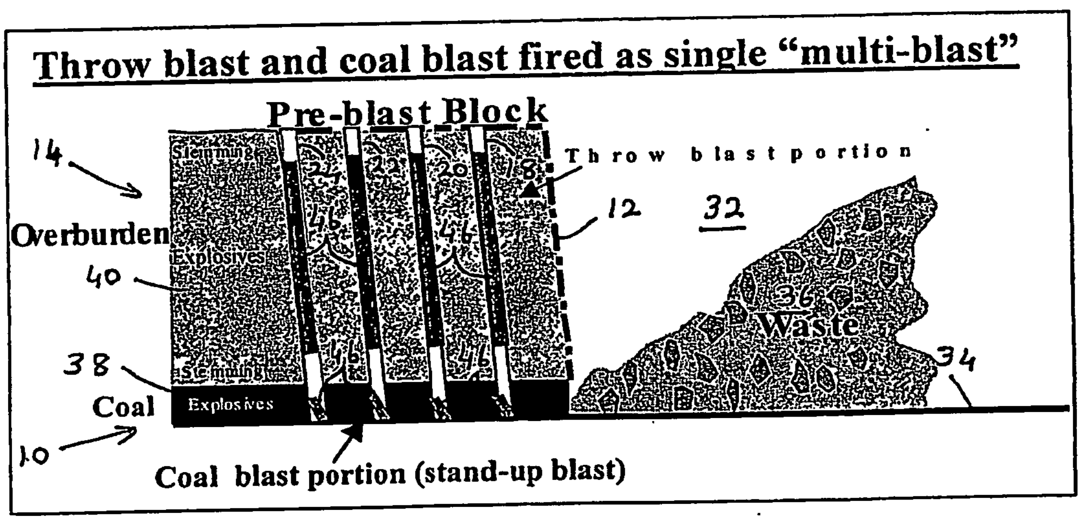

Figure 4

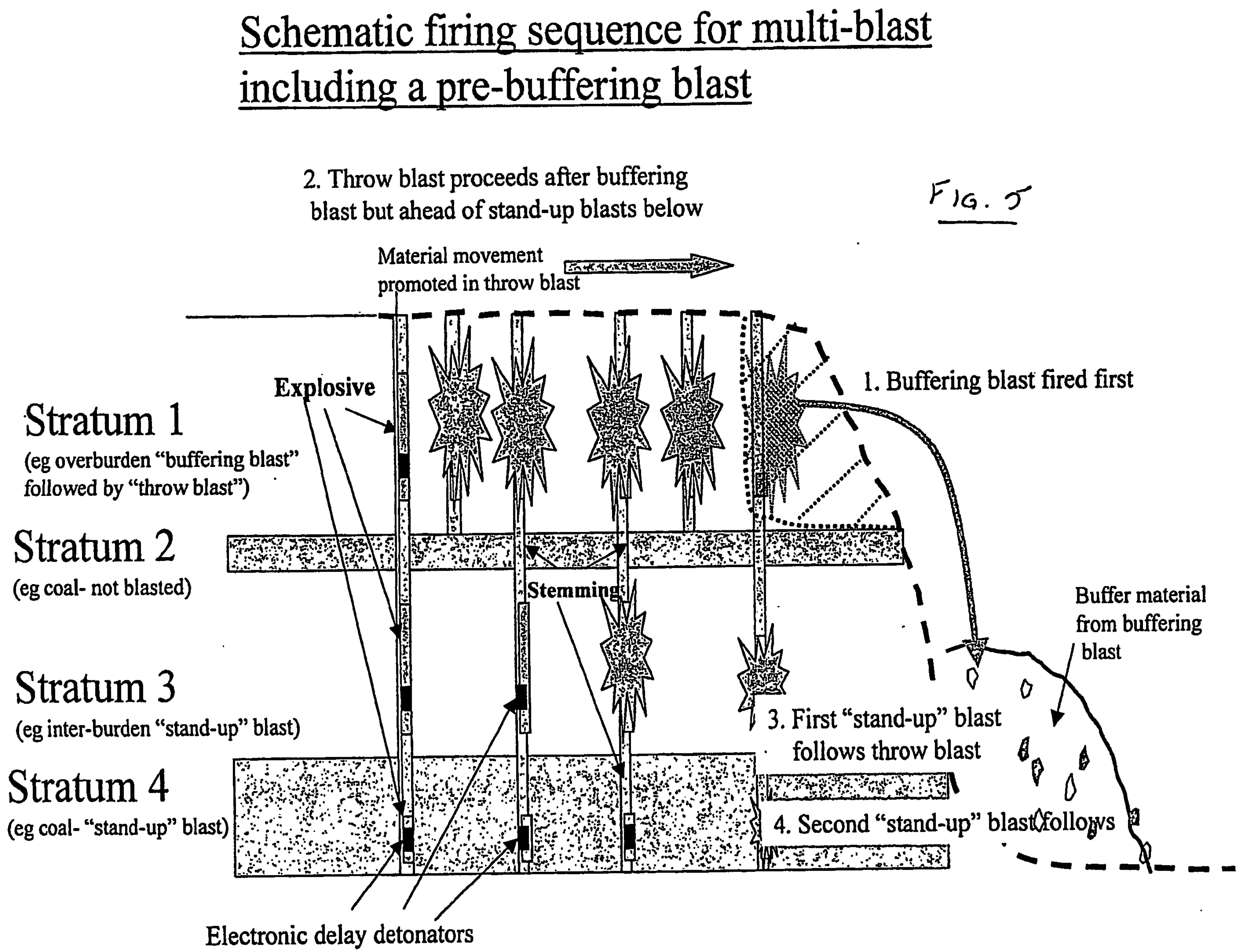
Schematic firing sequence for multi-blast
including a pre-buffering blast
2. Throw blast proceeds after buffering blast but ahead of stand-up blasts below
Material movement promoted in throw blast
Explosive
Stratum 1
(eg overburden "buffering blast" followed by "throw blast")
Stratum 2
(eg coal- not blasted)
Stemming
Stratum 3
(eg inter-burden "stand-up" blast)
Stratum 4
(eg coal- "stand-up" blast)
Electronic delay detonators
1. Buffering blast fired first
Buffer material from buffering blast
3. First "stand-up" blast follows throw blast
4. Second "stand-up" blast follows

FIG. 5

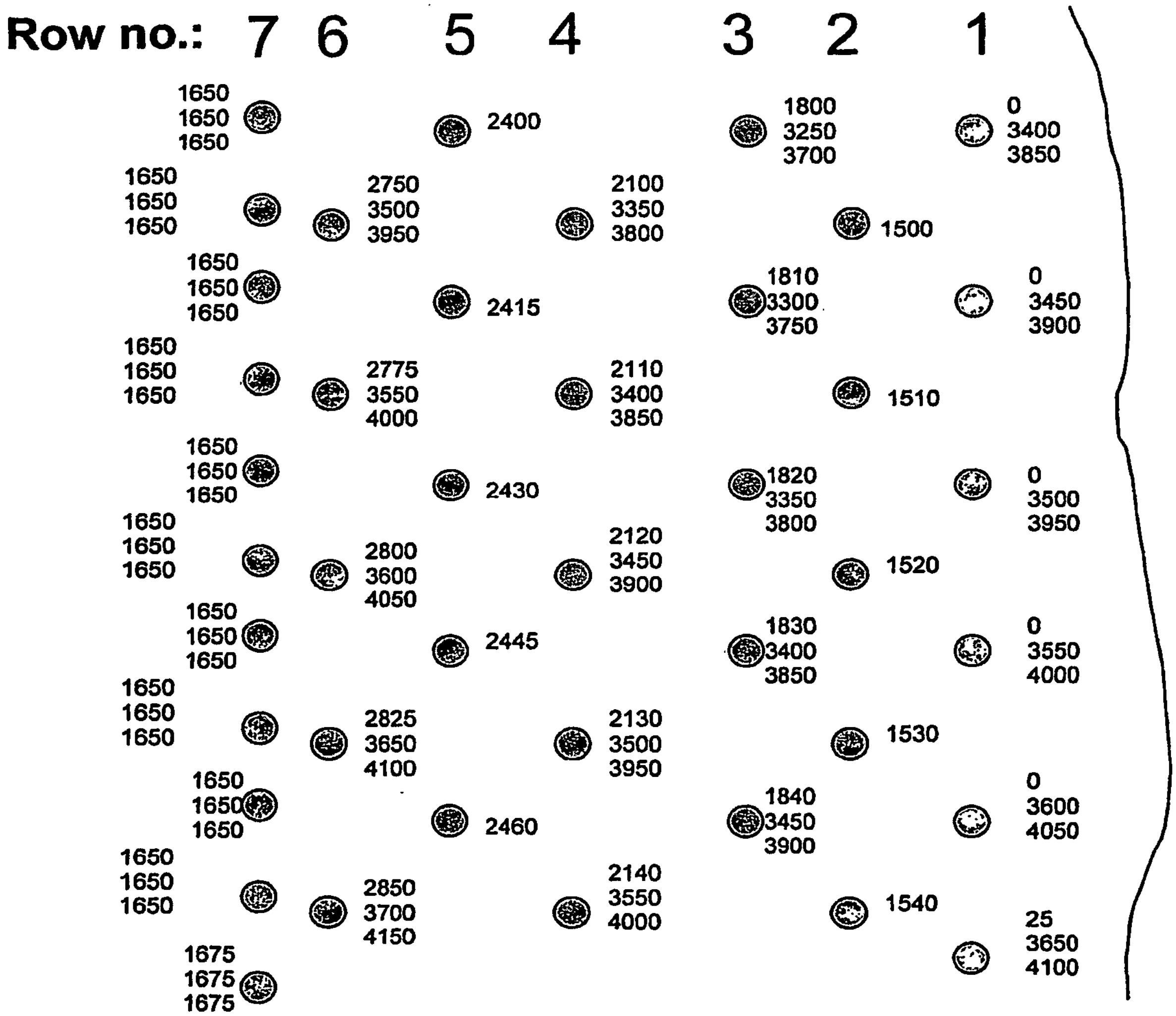

Figure 6 a. Plan view of multi blast

(Numbers alongside holes show initiation times of decks within holes, with uppermost deck initiation time shown first.)

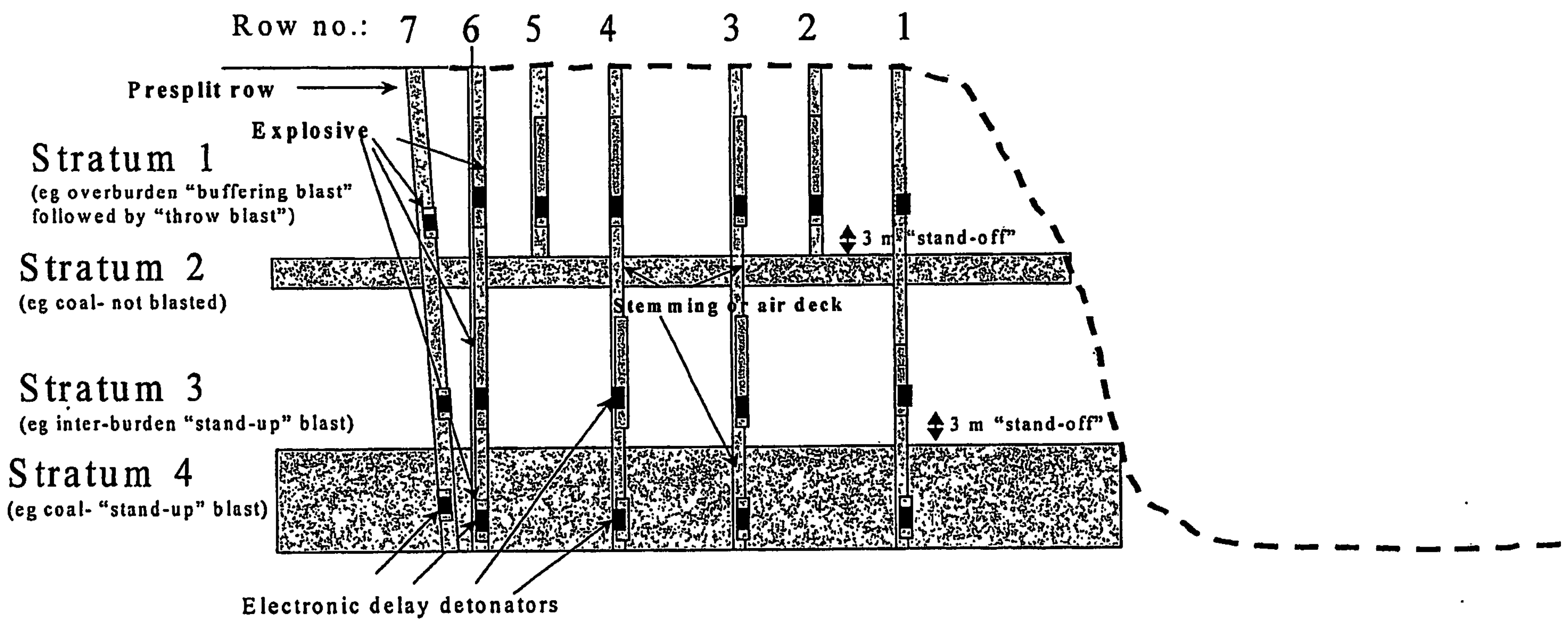

Figure 6 b Cross-sectional view of multi-blast

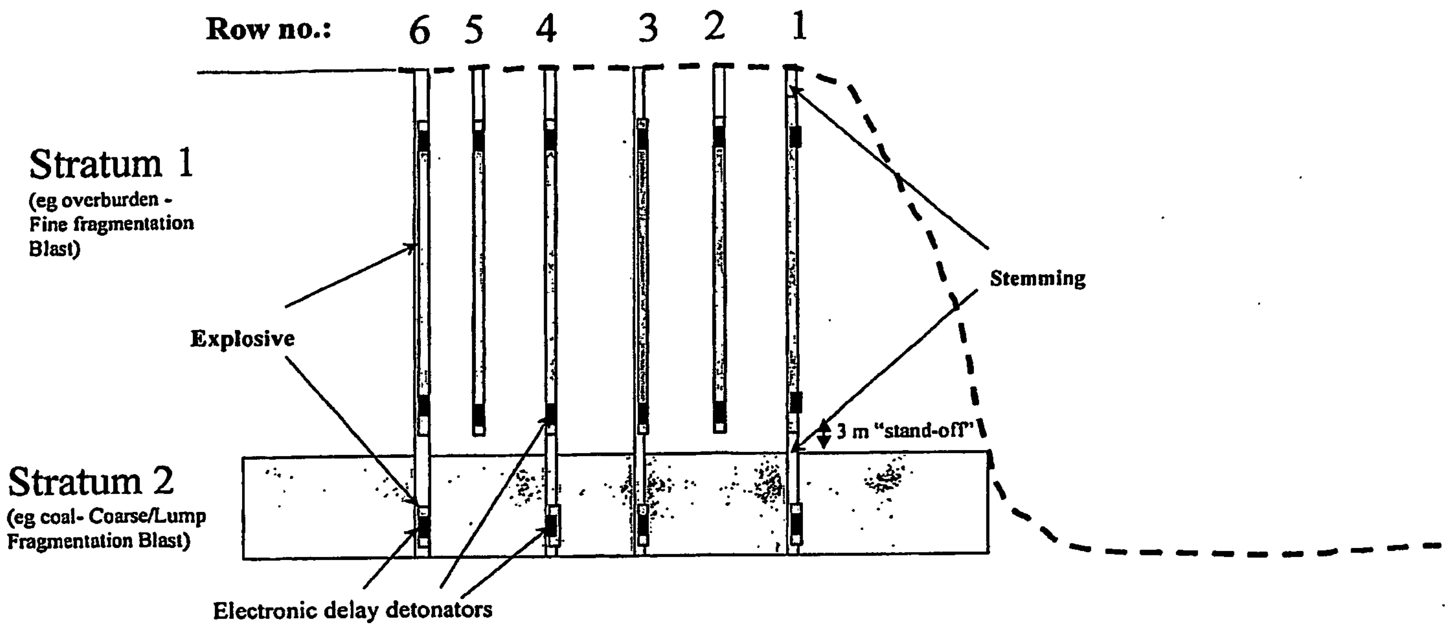

Figure 7 Cross-sectional view of multi-blast with differential fragmentation

Document made available under the Patent Cooperation Treaty (PCT)

International application number: PCT/AU04/001401

International filing date: 13 October 2004 (13.10.2004)

Document type: Certified copy of priority document

Document details: Country/Office: AU
Number: 2003906600
Filing date: 28 November 2003 (28.11.2003)

Date of receipt at the International Bureau: 08 November 2004 (08.11.2004)

Remark: Priority document submitted or transmitted to the International Bureau in compliance with Rule 17.1(a) or (b)

This Page is Inserted by IFW Indexing and Scanning Operations and is not part of the Official Record

BEST AVAILABLE IMAGES

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images include but are not limited to the items checked:

- ☑ BLACK BORDERS
- ☐ IMAGE CUT OFF AT TOP, BOTTOM OR SIDES
- ☐ FADED TEXT OR DRAWING
- ☐ BLURRED OR ILLEGIBLE TEXT OR DRAWING
- ☐ SKEWED/SLANTED IMAGES
- ☐ COLOR OR BLACK AND WHITE PHOTOGRAPHS
- ☐ GRAY SCALE DOCUMENTS
- ☑ LINES OR MARKS ON ORIGINAL DOCUMENT
- ☑ REFERENCE(S) OR EXHIBIT(S) SUBMITTED ARE POOR QUALITY
- ☐ OTHER: ______________________

IMAGES ARE BEST AVAILABLE COPY.
As rescanning these documents will not correct the image problems checked, please do not report these problems to the IFW Image Problem Mailbox.